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ANALYTICAL STUDY ON LIGHT GAUGE STEEL HOLLOW FLUTED COLUMNS UNDER AXIAL LOADING

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ABSTRACT

Cold-Formed Steel Columns (CFSC) have provided its usefulness in the structural applications of the constructions like individual structural framing members and panel decks. The advantage of cold rolled steel is that it can be utilized for the production of elements with required shape to length of required dimensions. High strength to weight ratio is achieved in cold-rolled products. In this project, an attempt has been made in order to investigate the axial load behavior of light gauge steel hollow fluted column. The behavior of columns is evaluated both theoretically and analytically using ANSYS and the results are compared. In the analytical work, nine sections were axially loaded and their corresponding axial shortening values are noted. From the results it is evident that at any particular load, the sections with flutes will have less axial shortening than sections without flutes and the axial shortening for rectangular fluted column (RFC) is less when compared to triangular fluted columns (TFC).The hollow columns (HC) having lesser seismic mass and the fluted columns with high strength and stiffness in combination with cold rolled steel structures makes the structure safer.

Key words: Cold-Formed Steel Columns, Ansys, Fluted Columns, RFC, TFC, Axial shortening.

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1. INTRODUCTION

Steel members are mostly used in all kind of structures because of its high strength to weight ratio which results in reduction of self weight. . In India the usage of CFS sections is growing rapidly, which is mainly used in storage racks, bracing members and hangers for roofs and trusses. Among all, cold formed steel sections are mainly used as secondary structural members such as purlins to support roof cladding. The thickness of steel sheet used in cold formed construction is usually 0.4mm to 6.4mm. Cold rolling shapes requires a series of shaping operations, usually along the lines of sizing, breakdown, roughing, semi-roughing, semi-finishing, and finishing. Most Greek and Roman columns were fluted - that means they had narrow channels running up and down them. Doric columns usually had 20 flutes, while Ionic columns usually had 24 flutes. Some flutes come to points between the flutes, while others have a flat top to each crest.

1.1. Specifications

The properties of the light gauge cold formed steel that are used in this project, is given in Table 1.

Table 1 Properties of Cold Formed Steel.

Yield Strength	210 N/mm^2
Modulus of Elasticity, E	2.0×10^5 N/mm^2
Poisson ratio	0.3

The test specimen details are given in Table 2.

Table 2 Specimens details

S. No	Name of the Specimen	Mean Diameter (mm)	Thickness (mm)	D/t ratio	Length (mm)
1	HCC (S1)	160	1.2	133	1000
2	HCC-RFC (S2)	160	1.2	133	1000
3	HCC-TFC (S3)	160	1.2	133	1000
4	HCC (S4)	160	1.6	100	1000
5	HCC-RFC (S5)	160	1.6	100	1000
6	HCC-TFC (S6)	160	1.6	100	1000
7	HCC (S7)	160	2	80	1000
8	HCC-RFC (S8)	160	2	80	1000
9	HCC-TFC (S9)	160	2	80	1000

Where, HCC- Hollow Circular Column, RFC- Rectangular Fluted Column and TFC- Triangular Fluted Column.

2. THEORETICAL STUDY

The present study is carried out to understand the behavior of cold formed light gauge steel using IS: 801-1975 & IS: 811-1987.

Specimen details:

- Length of column =1000 mm
- Diameter of column =160 mm
- Thickness of column
- Varies from =1.2 mm, 1.6 mm and 2 mm.
- Length of flute for RFC =30 mm

- Length of flute for TFC =40 mm
- Breadth of flute =20 mm

The ultimate load carrying capacity as per IS:801-1975 is shown in table 3

Table 3 Theoretical values using IS 801-1975 and IS 811-1987

S.No	Name of the specimen	Area (mm^2)	Moment of inertia (mm^4)	Safe load (kN)
1	S1	598.35	180×10^4	65.5
2	S2	853.51	4700×10^4	93.56
3	S3	709.96	3897×10^4	77.81
4	S4	796.21	250×10^4	87.26
5	S5	1135.5	4905×10^4	124.5
6	S6	943.95	4067×10^4	103.46
7	S7	992.74	310×10^4	108.8
8	S8	1416.29	5108×10^4	155.2
9	S9	1176.61	4235×10^4	128.96

3. FINITE ELEMENT METHOD

The finite element method is a numerical analyzing method to solve problems of Engineering applications. In recent days, the engineering problems make it required to get a numerical solution to problems. A finite element method is characterized by a variational formula, one or more solution algorithms and post-processing procedures. Then the original structure is the assemblage of these elements connected at a finite element analysis with a software of ANSYS R.15 which was used in this project.

The finite element model of all the specimens are shown in figure 1 to figure 9.

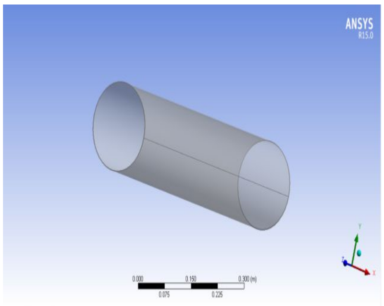

Figure 1 Hollow circular column without flutes

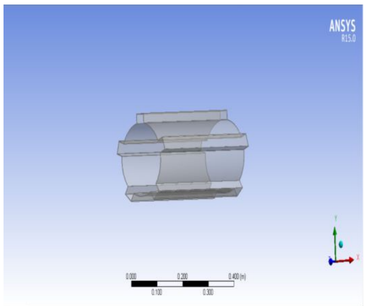

Figure 2 Hollow circular column with rectangular flutes

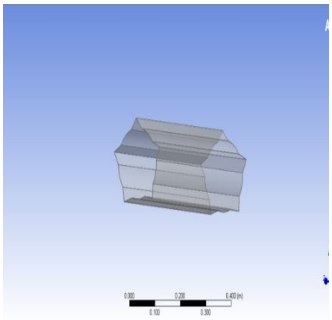

Figure 3 Hollow circular column with triangular flutes

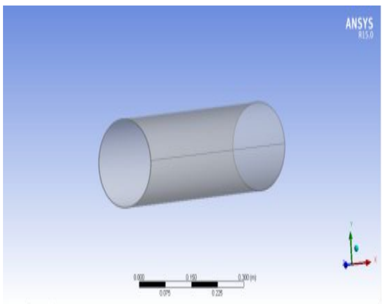

Figure 4 Hollow circular column without flutes

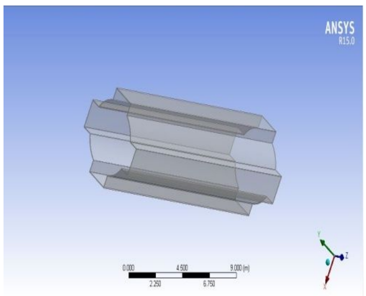

Figure 5 Hollow circular column with rectangular flutes

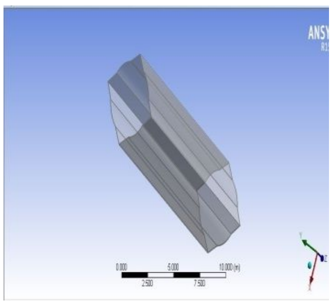

Figure 6 Hollow circular column with triangular flutes

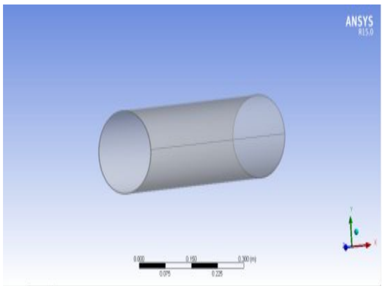

Figure 7 Hollow circular column without flutes

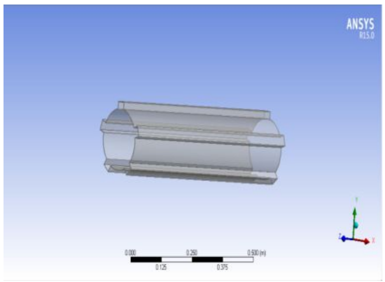

Figure 8 Hollow circular column with rectangular flutes

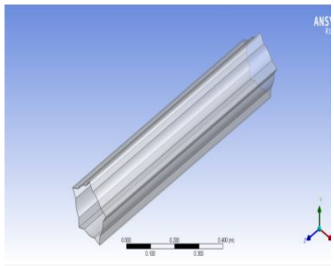

Figure 9 Hollow circular column with triangular flutes

4. RESULTS AND DISCUSSIONS

The analysis is carried out using Finite Element Method (FEM) software. The results of the models are discussed in terms of axial shortening. The analytical results of Light gauge cold formed hollow circular column with and without flutes are discussed and their results are shown below.

The deformed shapes for the various sections are shown in Figure 10 to Figure 18.

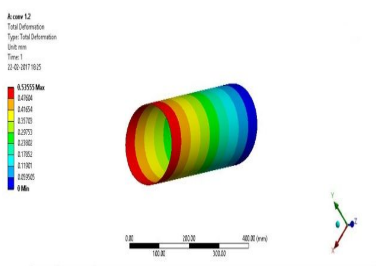

Figure 10 Axial shortening of hollow circular column without flutes.

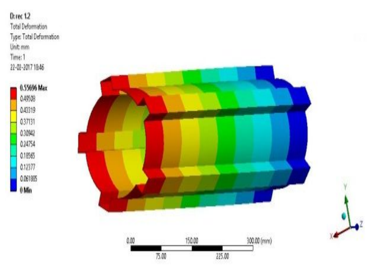

Figure 11 Axial shortening of hollow circular column with rectangular flutes.

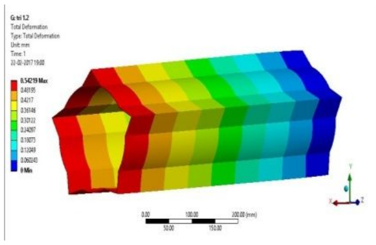

Figure 12 Axial shortening of hollow circular column with triangular flutes.

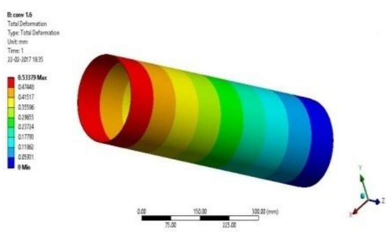

Figure 13 Axial shortening of hollow circular column without flutes.

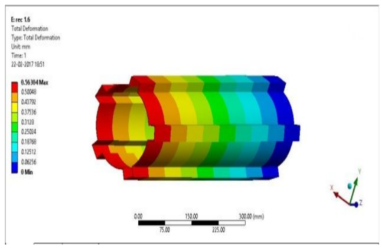

Figure 14 Axial shortening of hollow circular column with rectangular flutes.

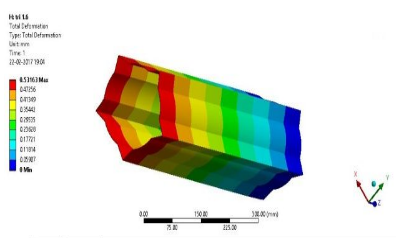

Figure 15 Axial shortening of hollow circular column with triangular flutes.

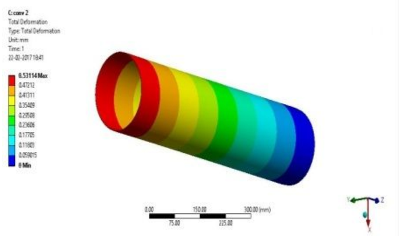

Figure 16 Axial shortening of hollow circular column without flutes.

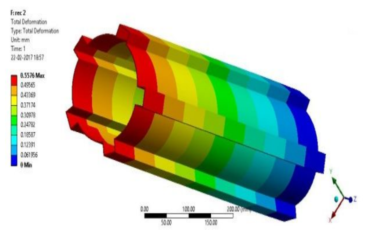

Figure 17 Axial shortening of hollow circular column with rectangular flutes.

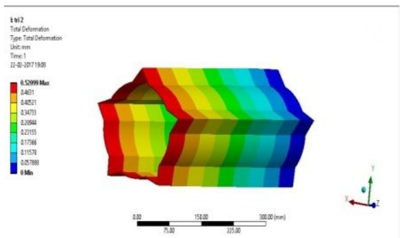

Figure 18 Axial shortening of hollow circular column with triangular flutes.

The LOAD VS AXIAL SHORTENING graph in Figure 19 is to show the axial shortening values of hollow circular columns with and without flutes of steel core thickness 1.2 mm.

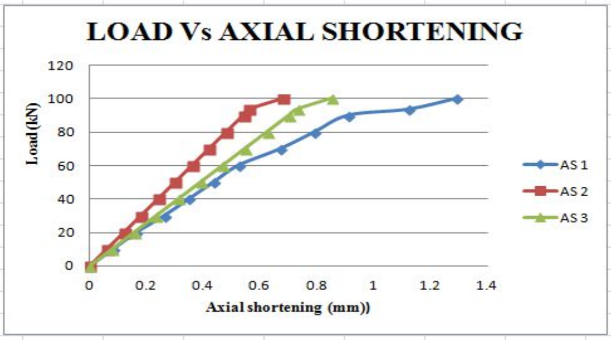

Figure 19 Load Vs Axial shortening graph

Where,

AS 1- Axial shortening values of hollow circular column without flutes.

AS 2- Axial shortening values of hollow circular column with rectangular flutes.

AS 3- Axial shortening values of hollow circular column with triangular flutes.

From the graph, it is evident that the columns with flutes have lesser axial shortening values than the column without flutes. The column with rectangular flutes and triangular flutes have 50% and 34.82% lesser axial shortening values when compared to column without flutes respectively and the column with rectangular flutes have 23% lesser axial shortening values as compared to the column with triangular flutes.

The LOAD VS AXIAL SHORTENING graph in Figure 20 is to show the Axial shortening values of hollow circular columns with and without flutes of steel core thickness 1.6 mm.

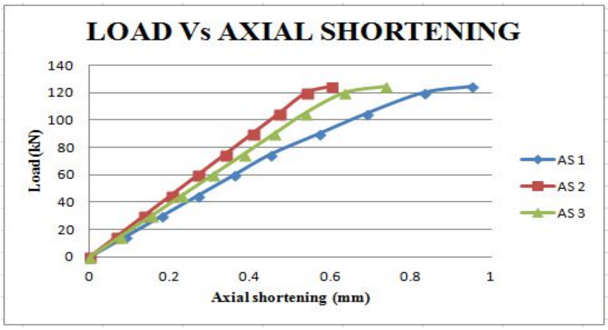

Figure 20 Load Vs Axial shortening graph

Where,

AS 1- Axial shortening values of hollow circular column without flutes.

AS 2- Axial shortening values of hollow circular column with rectangular flutes.

AS 3- Axial shortening values of hollow circular column with triangular flutes.

From the obtained results, as the thickness of the steel core is increased, there is a reduction in Axial shortening values when compared to the steel core with 1.2 mm. The column with rectangular flutes and triangular flutes have 36.8% and 23.15% lesser axial shortening values when compared to column without flutes respectively and the column with rectangular flutes have 17.88% lesser axial shortening values as compared to the column with triangular flutes.

The LOAD VS AXIAL SHORTENING graph in Figure 21 is to show the axial shortening values of hollow circular columns with and without flutes of steel core thickness 2 mm.

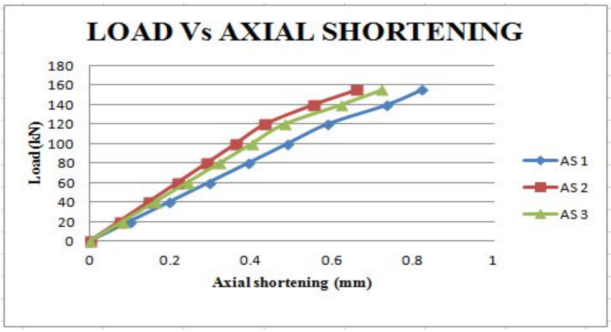

Figure 21 Load Vs Axial shortening graph

Where,

AS 1- Axial shortening values of hollow circular column without flutes.

AS 2- Axial shortening values of hollow circular column with rectangular flutes.

AS 3- Axial shortening values of hollow circular column with triangular flutes.

The column with rectangular flutes and triangular flutes have 20.73% and 12.19% lesser axial shortening values when compared to column without flutes respectively and the column with rectangular flutes have 9.7% lesser axial shortening values as compared to the column with triangular flutes.

The stress values acquired from the corresponding load cases are tabulated in table 4

Table 4 Stress Values

S. No	Name of the specimen	Stress (MPa)
1	S1	109.46
2	S2	118.66
3	S3	116.74
4	S4	109.59
5	S5	119.15
6	S6	117.09
7	S7	109.69
8	S8	119.6
9	S9	117.91

From the table 4.1, the stress value of S2 is 7.75% and 1.6% more than S1 and S3 respectively. The stress values of S5 is 8.02% and 1.7% more than S4 and S6 respectively. The stress values of S8 is 8.3% and 1.4% more than S7 and S9 respectively.

The strain values acquired from the corresponding load cases are tabulated in table 5

Table 5 Strain values

S.No	Name of the specimen	Strain
1	S1	0.00062
2	S2	0.00056
3	S3	0.00059
4	S4	0.00061
5	S5	0.00059
6	S6	0.00060
7	S7	0.00061
8	S8	0.00058
9	S9	0.00059

From the table 4.2, the strain value of S2 is 10.7% and 5.08% less than S1 and S3 respectively. The strain values of S5 is 3.2% and 1.7% less than S4 and S6 respectively. The strain values of S8 is 4.9% and 1.7% less than S7 and S9 respectively.

5. CONCLUSION

Analytical and Theoretical investigations were carried out to make a comparative study on the behavior of light gauge cold-formed hollow circular column with and without flutes and following conclusions were drawn.

- For hollow light gauge steel column of thickness 1.2 mm, the maximum axial shortening values of rectangular flutes and triangular flutes to that of hollow circular column have 50% and 34.82% lesser when compared to hollow circular column without flutes respectively.
- For hollow steel column of thickness 1.6 mm, the maximum axial shortening values of rectangular flutes and triangular fluted column to that of hollow circular column have 36.8% and 23.15% lesser when compared to hollow circular column without flutes respectively.
- For hollow steel column of thickness 2 mm, the maximum axial shortening values of rectangular flutes and triangular fluted column to that of hollow circular column have 20.73% and 12.19% lesser when compared to column without flutes respectively.
- From the above results, the maximum axial shortening values obtained for the hollow circular column with rectangular and triangular flutes is always lesser than the hollow circular column without flutes and the axial shortening values reduces with increase in thickness of specimen.
- Also, the maximum axial shortening of hollow circular column with rectangular flutes is quiet lesser than the hollow circular column with triangular flutes.
- The stress values obtained for hollow circular column with flutes is greater than the hollow circular columns without flutes and the columns with rectangular flutes is found to have an increased stress values than columns with triangular flutes.
- The strain values obtained shows that the hollow circular column with flutes is found to have lesser strain as compared to the columns without flutes.
- The hollow circular columns with rectangular flutes are having quiet lesser strain values as compared to that of columns with triangular flutes.
- From all the above conclusions, it is clear that the hollow circular columns with flutes is behaving better when compared to hollow circular column without flutes and the columns with rectangular flutes is found to have increased strength to the hollow circular columns with triangular flutes.

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